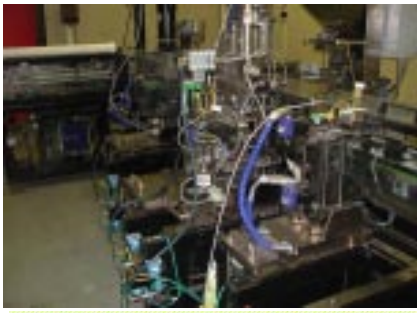

ZIGGY™

ZIGGY LEAN Overview

Lean manufacturing training calls out the five (5) steps leading to Lean:

1. Specify Value
2. Identify the Value Stream
3. Flow
4. Pull
5. Pursue Perfection

But how does one implement Flow? How does one implement Pull? Lean teaches us that the ideal would be a lot size of "1". How does one get to a lot size of "1" without huge expense?

ZIGGY is a manufacturing architecture comprised of rules, concepts, software, and hardware that helps companies economically achieve the ideal.

The building blocks of this architecture are:

- Modular process units
- Modular train units
- Modular conveyance
- Agile Controller
- Mass Customization Controller

The unifying elements include open-architecture controls, communications, and software

Each of these components will be described in more detail in subsequent documents. The objective here is to provide an overview.

An assembly line implemented using ZIGGY can instantaneously change from making one product to another to another without stopping and without setup.

Move from high-volume, high-speed, mass production, to a lot size of "1" and return without interruption. This capability allows companies to build to order, to match inventory tocustomer demand, to personalize their products and services to better serve their customers.

Implement ing ZIGGY guides a company to design in Flow and Pull—even in low-volume, batch production.

Companies implementing ZIGGY will:

- Lower production costs
- Reduce inventory costs
- Improve Cash Flow
- Develop closer relations with their customers
- Achieve dependable delivery schedules

ZIGGY LEAN has a consistent set of components used to build an assembly line from the bottom up.

Modular Process Units

- The lowest level of production. These are fully self-contained single-step production machines designed to your production requirements.
- Each Modular Process Unit is designed to a common set of physical characteristics selected for compatibility with your requirements.
- A WRC HOLOCON™ Controller is used within each Unit to provide the controls necessary for autonomous operation of the unit, but integrated with the balance of the line for coordination and step-wise negotiation. The HOLOCON controller is designed to the open-standard IEC 61499

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Modular Process Train Units

- Multiple Modular Process Units may be ganged
- together to meet speed, timing, and/or volume requirements.
- In this case, groups of products may be moved together— as in a train.
- A WRC HOLOCON controller provides the control of a train unit.

Modular conveyance

- The conveyance also needs to be designed for the family of products being produced.
- To meet the ZIGGY Architecture requirements, the conveyance and the Process Units must be operated independently and be mechanically independent.
- A wide variety of options are available including conveyors, material handling robots, even direct labor.

AGILE Controller

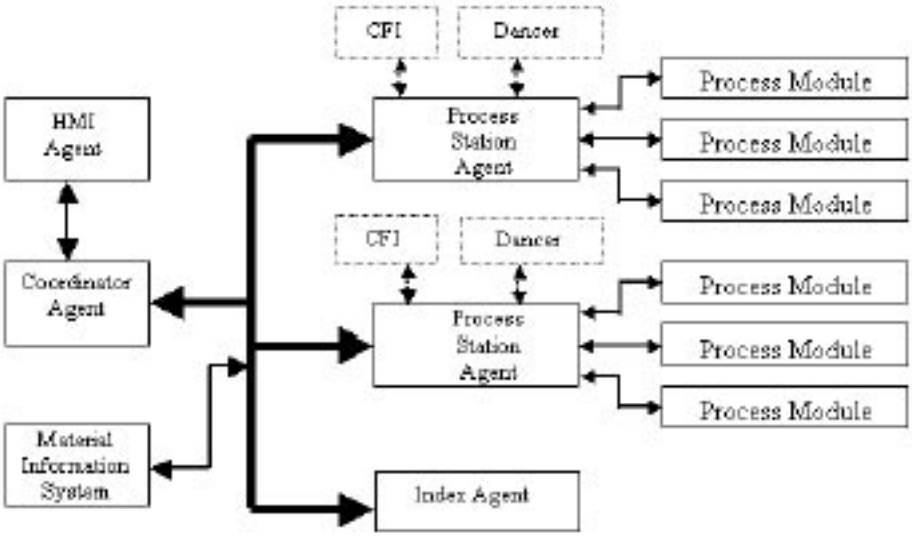
- The AGILE Controller is the heart of the architecture.
- The AGILE Controller communicates with each of the HOLOCON Controllers in the Modular Process
- Units and the Modular Train Units and the Modular Conveyance to provide operational synchronization.
- Additional communications take place for error handling and to negotiate the change or introduction of a new Modular Process Unit.

Mass Customization Controller

The optional Mass Customi z a t ion Controller communicates with the AGILE Controller and the HOLOCON Controllers to direct them when it is their turn to operate on a production piece.

Using a combination of recipes and itineraries the Mass Customization Controller controls the operations per - formed during assembly thus allowing each piece to be processed differently resulting in a batch size potential of "1".

The unifying elements include open-architecture controls, communications, and software.

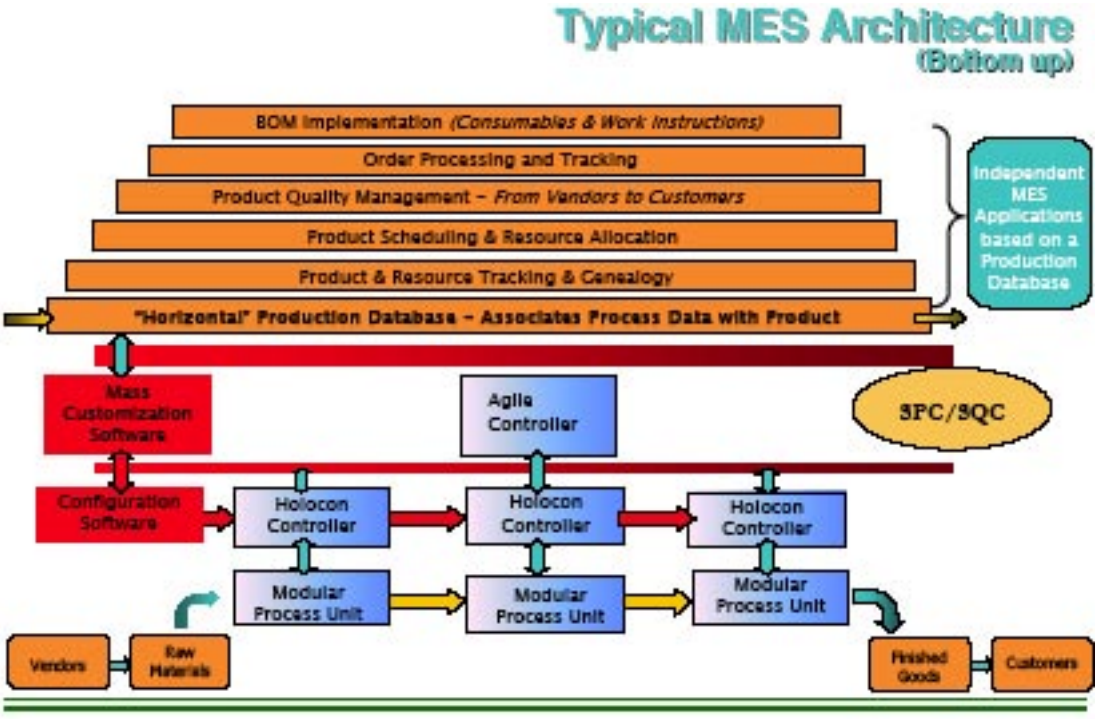


Open-Architecture Controls: The HOLOCON Controllers are designed to the Open-Architecture standard IEC 61499. This standard was generated for the express purpose of highly distributed controls—the primary and unique characteristic of the ZIGGY architecture.
Control development uses graphical pointand- click funct ion blocks with interco nections and data flow provided graphically. The program is then downloaded to the HOLOCON Controller where it is embedded for fast, reliable startup.

Open-Architecture Communications: Communications follow the Ethernet-IP standard to enable easy integration with external software and other plant controls. This standard is maintained by the ODVA, Open DeviceNet Vendors Association.

Open-Architecture Software:

- The AGILE Software and the Mass Customization software are patented.
- The software is written in the open standard programming language of JAVA. One of the



many features of JAVA is that it is highly transportable between operating systems. This provides a foundation of stability and long-term confidence.

- However, as with all software, improvements are continually being provided. Accordingly, an option for a software maintenance contract is available.

ZIGGY LEAN is unique.

- It is a proven architecture and product suite
- The principles behind ZIGGY can be applied to most manufacturing/ assembly operations
- The AGILE software and the Mass Customization software are standard, off-the-shelf packages
- The teaming of a controls company specializing in AGILE Manufacturing and Mass Customization with a machine builder or systems integrator knowledgeable in your production processes provides the best of both worlds. ZIGGY LEAN advantages:
- An off-the-shelf solution costs less to implement
- An off-the-shelf solution takes less time to implement thus getting you to market sooner
- An off-the-shelf solution carries less risk
- An open-architecture solution is easier for your staff to support
- An open-architecture solution means futureenhancements will be easier to implement
- Teaming between the controls supplier and the integrator we know means a shorter project cycle with an easier hand-off to production personnel.
- Browsers can be utilized to access the status of the production line from any secure internet connection providing greater management visibility.
- Utilizing open - architecture software standards, ZIGGY can be seamlessly integrated with most Manufacturing Execution Software (MES) provided by companies such as SAP, Oracle, and Rockwell Automation.

Find more on IEC 61499 Compliant Controllers
at http://www.wrcakron.com/holocon.html

ZIGGY™ LEAN - Modular Process Units

The Modular Process Unit is the workhorse of the ZIGGY Architecture.

The operational concept is to process an article by sending it through a series of manufacturing steps. Each step is performed by a Modular Process Units (MPU).

Since different articles require different manufacturing steps, the MPU is selected— or designed—to meet the needs of the article being manufactured.

For example, if the article being manufactured is candy, the MPUs will be different from ones used to make lightbulbs.

Accordingly, WRC works with the end user to select a machine builder or systems integrator that can supply the MPUs needed for their process. The criticalconsideration is that certain common characteristics are required in order for the MPUs to be integrated into a ZIGGY Architecture.

The common characteristics include:

- Standardized physical interface to allow easy interchangeability of MPUs.
- Controls embedded within the MPU
- Self-contained MPU including sensors, actuators, power supply
- Standardized external interfaces including Ethernet connections, power, air, hydraulics, etc.
- The MPU and the Modular Conveyance are to operate independently
- Either a HOLOCON controller or an IEC 61499 Proxy interface to the MPU.

The article being manufactured is to be moved between MPUs in order for the processing steps to be performed. The controls are to be designed to independently perform their operation when instructed by the AGILE Controller and the Mass Customization Controller.

Status and error messages will be passed to the AGILE Controller, the Mass Customization Controller, and to other MPUs.

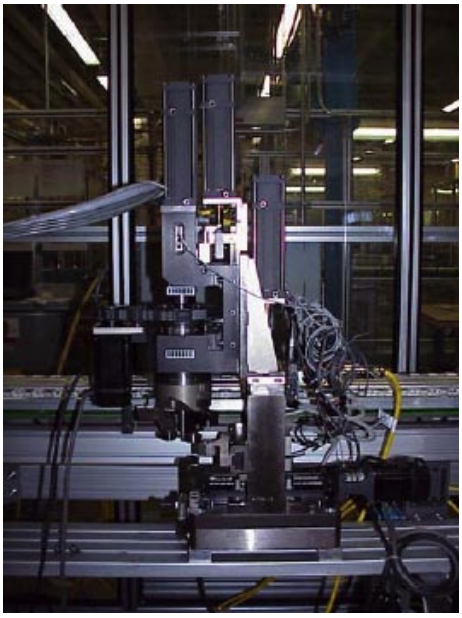
During start-up, software negotiations will be conducted between the MPUs, the AGILE Controller, and the Mass Customization

Controller addressing the capability of the MPU and its status. This negotiation provides the AGILE Controller and the Mass Customization

Controller with the information they need to manage the overall productionline. These negotiations are implemented using Agent-Based Software and are resident in the HOLOCON Controller or IEC 61499 Proxy.

The MPU rules are established for a number of reasons:

- The objective is AGILE Manufacturing—as a minimum.
- Possibly, Mass Customization is desired
- In either case, we can be guaranteed that at some point in time a process or product change will be required.
- The primary objective behind the ZIGGY MPU rules is to be able to implement changes without disrupting operations elsewhere in the process.



Sealer A

As an illustration, refer to the two photos of sealing MPUs. A client had been using sealer A. It did the job. It was in place. But sealer A operated by stamping. There was some indication that the seal would be stronger and last longer if it was rolled instead of stamped.

In a conventional assembly line, it would be disruptive to consider making such an incremental change. Production would be interrupted for days. Other equipment would have to be moved with the potential for introducing damage and additional delays. And if the new design did not work out for some reason, it would be disruptive to return production to the original condition.

Interchangeable Sealer B made possible by ZIGGY

With ZIGGY, the customer built up a new sealer B that rolled the part closed.

Since A and B followed the same mechanical footprint, they were interchangeable.

Since they followed the same standards for electrical, communications, and air connections, they were interchangeable. And since they both followed the Agent-based software interface standard, one could be substituted for the other.

In fact, with only 5 minutes of downtime, the two units were swapped and the line was back in operation.

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ZIGGY™

ZIGGY™ LEAN - Modular Conveyance

The Modular Conveyance provides the interlocking over the ZIGGY Architecture.

The operational concept is to process an article by sending it through a series of manufacturing steps.

Each step is performed by a Modular Process Units (MPU). The Modular Conveyance (MC) moves the article between MPUs.

Since different articles require different manufacturing steps, the MC is selected— or designed—to meet the needs of the article being manufactured. For example, if the article being manufactured is batteries, the MC will be different from ones used to make Auto Compressors.

Accordingly, WRC works with the end user to select a material handling firm or systems integrator that can supply the MCs needed for their process. The critical consideration is that certain common characteristics are required in order for the MCs to be integrated into a ZIGGY Architecture.

The common characteristics include:

- The MPU and the Modular Conveyance are to operate independently
- Standardized physical interface to allow easy interchangeability of MPUs and to simplify the material handling
- Controls embedded within the MC
- Self-contained MC including sensors, actuators, power supply
- Either a HOLOCON controller or an IEC 61499 Proxy interface to the MC.

The article being manufactured is to be moved by the MC between MPUs in order for the processing steps to be pe formed.

The MC controls are to be designed to independently perform their operation when instructed by the AGILE Controller and the Mass Customization Controller.

Status and error messages will be passed to the AGILE Controller, and to the Mass Customization Controller.

During start-up, software negotiations will be conducted between the MC, the MPUs, the AGILE Controller, and the Mass Customization Controller addressing the capability of the MC, the MPU and its status. This negotiation provides the AGILE Controller and the Mass Customization Controller with the information they need to manage the overall production line. These negotiations are implemented using Agent- Based Software and are resident in the HOLOCON Controller or IEC 61499 Proxy.

There is a lot of flexibility within the ZIGGY architecture regarding the MC. For example, the MC could be based on an automated conveying system for the highest speed and lowest labor content. Or it could be based on a robotic handling system for complex parts. Some companies have used a roller-based mechanical conveyor using tooling jigs to position the articles as they progress through the cell.

In any of these cases, WRC works with the manufacturer, the integrators, and the equipment suppliers to assure compatibility within the ZIGGY Architecture.

The MC rules are established for a number of reasons:

- The objective is AGILE Manufacturing—as a minimum.
- Possibly, Mass Customization is desired
- In either case, we can be guaranteed that at some point in time a process or product change will be required.
- The primary objective behind the ZIGGY MC rules is to be able to implement changes without disrupting operations elsewhere in the process.

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ZIGGY™

ZIGGY™ LEAN - AGILE Controller

The AGILE Controller is the heart of the ZIGGY Architecture.

The operational concept is to process an article by sending it through a series of manufacturing steps. Each step is performed by a Modular Process Units (MPU) under the direction of the AGILE Controller.

The AGILE Controller is an agent-based software program that runs on an embedded computer running a real-time operating system. It communicates over Ethernet with each of the MPUs. It directs them as to when it is time for them to perform their operations. This timing is determined by understanding the status of each of the MPUs. When they have all reported that they have properly completed their previous operations, then the AGILE Controller will instruct the MC to move the articles. When the MC reports that the articles have been moved, then the AGILE Controller directs the MPUs that it is ok to perform their operation again.

In order to handle error messages indicating that an MPU did not successfully complete its operation, the AGILE Controller tracks each item through all of the manufacturing steps and tags any items to be rejected.

This tracking and tagging capability can be integrated with techniques for handling high volumes of production that normally would require an accumulator. Think of it as a dynamic accumulator that can accommodate individual article tracking.

During start-up, software negotiations will be conducted between the MC, the MPUs, the AGILE Controller, and the Mass Customization Controller addressing the capability of the MC, the MPU and its status. This negotiation provides the AGILE Controller and the Mass Customization Controller with the information they need to manage the overall production line. These negotiations are implemented using Agent-Based Software. The AGILE Controller learns everything it needs to learn from a properly implemented MPU. This means that the AGILE Controller is a standardized software package that can be applied across a wide range of manufacturing applications.

The result is:

- Lower initial cost
- Faster implementation
- Shorter time to market
- Lower ongoing expenses
- The use of open standards means that factory- floor support is readily available
- Simpler integration with balance of plant information systems.

The objective of Agile Manufacturing is to be able to make incremental changes to the product or the process quickly and easily. The Architecture of ZIGGY and the software provided by the AGILE Controller makes this possible.

Whenever a new MPU is introduced into the assembly line, the AGILE Controller negotiates with the embedded HOLOCON Controller to learn what the MPU is, what it is capable of, how to exploit that capability, and how to integrate the MPU with the rest of the assembly line. The AGILE Controller then reorganizes itself to incorporate that which was learned. In this manner, incremental changes to the product and the process can be introduced with a minimum of downtime, a minimum of engineering and operations involvement, and with a minimum of expense.

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ZIGGY™

ZIGGY™ LEAN - Mass Customization Controller

The Mass Customization Controller is the brains of the ZIGGY Architecture.

The operational concept is to process an article by sending it through a series of manufacturing steps. Each step is performed by a Modular Process Units (MPU) under the direction of the AGILE Controller. Meanwhile, the Mass Customization Controller maintains a recipe for different items that can be built and an itinerary for building those items.

The Mass Customization Controller is an agentbased software program that runs on an embedded computer running a realtime operating system. It communicates over Ethernet with each of the MPUs. Using the knowledge that is dynamically maintained, it understands the capabilities of each of the MPUs and it understands the status of each item being produced.

From the itinerary and the recipe, the Mass Customization Controller dynamically assigns to each item under production a recipe.

As the individual item is being processed, it then instructs the individual MPUs how to operate. For example, the line may be producing red widgets. An order arrives for three bluewidgets. If the Mass Customization Controller determines that the blue widget making MPU is available, it will set an itinerary for three widgets to not be processed by the red MPU, but instead be processed by the blue MPU. Three pieces— *made to order.*

Production matching demand. No excess inventory. No inventory shortages.

Happy customers and management— because of the overall operational efficiency of the ZIGGY process.

How it works

During start-up, software negotiations will be conducted between the MC, the MPUs, the AGILE Controller, and the Mass Customization Controller addressing the capability of the MC, the MPU and its status.

This negotiation provides the AGILE Controller and the Mass Customization Controller with the information they need to manage the overall production line.

These negotiations are implemented using Agent- Based Software.

The Mass Customization Controller learns everything it needs to learn from a properly implemented MPU. This means that the Mass Customization Controller is a standardized-software package that can be applied across a wide range of manufacturing applications.

The result is:

- Lower initial cost
- Faster implementation
- Shorter time to market
- Lower ongoing expenses
- The use of open standards means that factory- floor support is readily available
- Simpler integration with balance of plant information systems.

Illustrated are operational displays for defining recipes and for running itineraries.

A recipe will identify each MPU. Associated with each MPU is a directive on how the MPU is to operate on the item. For example, the directive may be to inhibit. Or it could be to operate three times—or only once. In this manner, the cumulative effect of the sequence and the operations determine what product is built.

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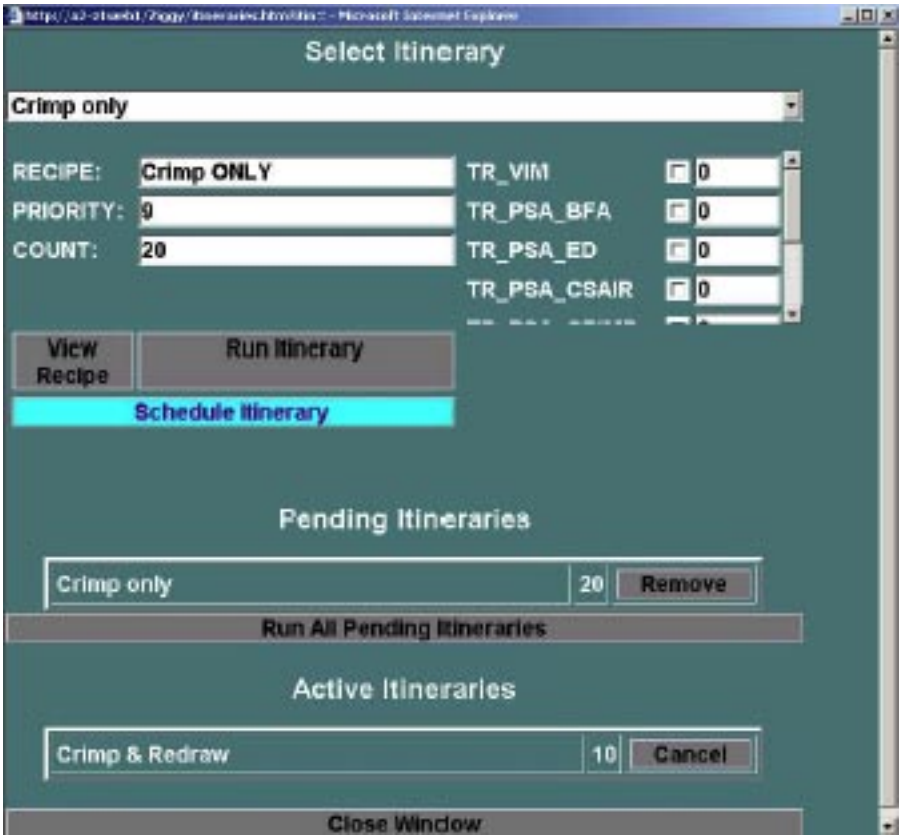


Also provided is an Itinerary. The itinerary identifies the recipe to be followed, how many items, the priority of making these items, when it is to be scheduled to run, and its current status.

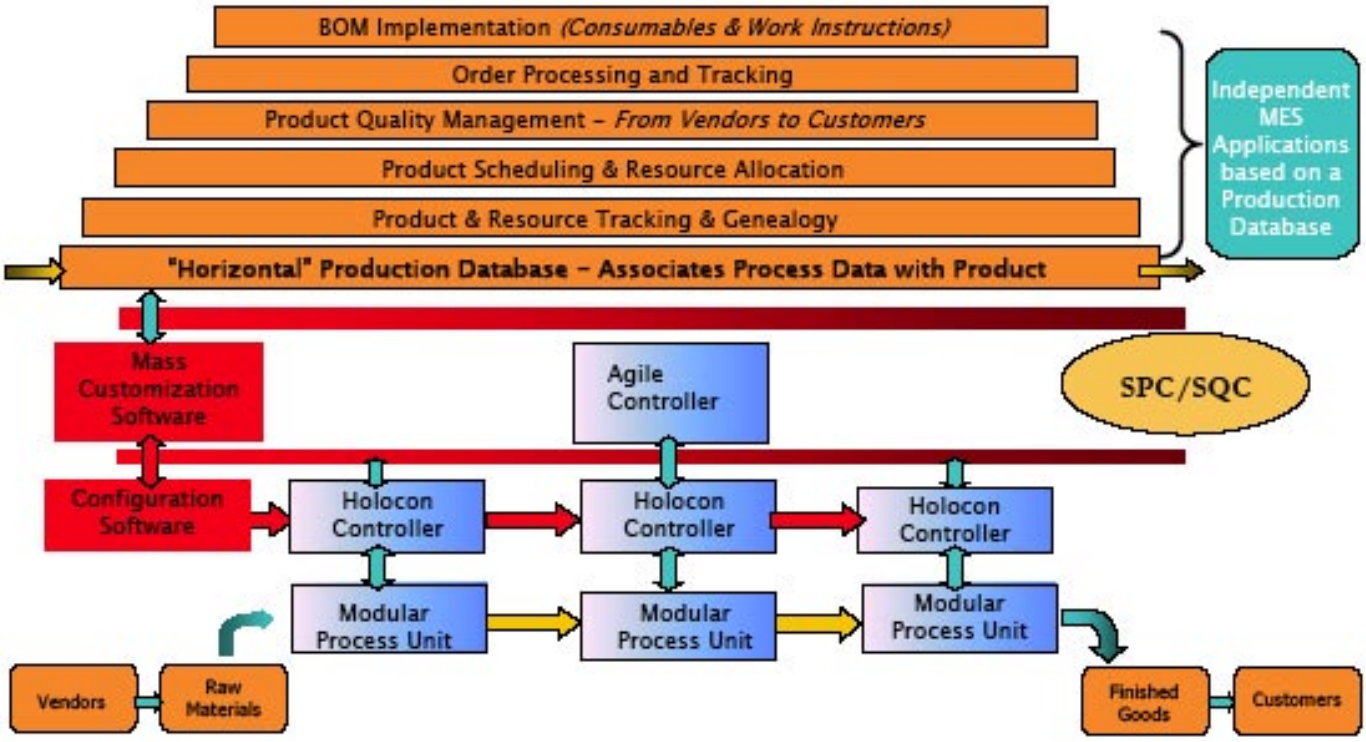
One can think of an itinerary as a work order with the recipe being the pick list of materials and operations.

ZIGGY can be integrated with the Company's Manufacturing Execution Software (MES) provided by companies such as SAP, Oracle, or Rockwell Automation.

Since ZIGGY is written in open-architecture languages and follows open-architecture software rules, the interface is typically provided using SQL calls to the plant database.

WRC will work with the System Integrator to provide the linkages necessary to meet the production strategy of the end user.

Typical MES Architecture (Bottom up)



ZIGGY™ LEAN - Process Station Controller

The Process Station Controller is like a foreman within the ZIGGY Architecture.

The operational concept is to process an article by sending it through a series of manufacturing steps. Each step is performed by a Modular Process Units (MPU) under the direction of the AGILE Controller. When there is a need for multiple, coordinated MPUs, that coordination is done by a Process Station Controller.

Multiple, coordinated MPUs may be desired for a number of reasons:

- To increase volume, MPUs may be ganged— like a train at a station
- To handle a timeconsuming task, multiple MPUs may desired
- To consume dead-time while waiting for another operation, timing constraints may suggest multiple MPUs.

The situation with multiple MPUs is a special case requiring a specialized controller. From the perspective of the Mass Customization Controller and the AGILE Controller, they would like to think of the process step as a single step instead of a gang of MPUs in parallel.

Accordingly, the Process Station Controller is built into a HOLOCON Controller for the express purpose of coordinating a parallel arrangement of MPUs. This means that the Process Station Controller is a standardized software package that can be applied across a wide range of manufacturing applications.

The result is:

- Lower initial cost
- Faster implementation
- Shorter time to market
- Lower ongoing expenses
- The use of open standards means that factory- floor support is readily available
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